

Evaluation of Programming Tools for the Development of Fuzzy-QFD Driven Software Tool for Effective Design of Online Shopping Websites

Ashish K. Sharma, Dr. Sunanda P. Khandait

Abstract— Today, the website design has emerged as major driving force behind the success of online shopping websites. This has forced designers and engineers to look for some novel methods for well designed websites. Recently the use of Quality Function Deployment (QFD) has been reported to yield better results in this regard. Albeit QFD greatly aids in effective website design, it follows crisp approach that gives rise to uncertainty and vagueness. Thus, the results of QFD can be greatly improved if uncertainty and vagueness involved can be suitably handled. Fuzzy set theory is one of the widely used techniques that can better address this issue. Moreover, QFD comprises of several matrices, is a lengthy process which involves massive data and complex calculations. As a result, dealing with the data manually is quite cumbersome and time consuming. Also, the available QFD softwares are restricted in functionality and even lack the fuzzy support. This generates a need for a Fuzzy QFD (FQFD) driven software tool for effective design of online shopping websites. However, development of software tool can be accomplished through the use of suitable programming tools. To this end, the paper discusses QFD at length, analyzes it against proposed software tool development. The paper then considers some programming tools and through comparative analysis attempts to evaluate out the most apt one for the proposed software tool.

Index Terms— Crisp, Fuzzy, Online Shopping, Programming Languages, Quality Function Deployment; QFD, Software, Websites Designing.

I. INTRODUCTION

In the recent past, due to technological advancements there has been a tremendous rise in the use of online shopping. Online shopping is far better than traditional shopping as everything is available to us at our door step just with the availability of Internet [1]. There are several factors that have contributed in the growth of online shopping - busy lifestyle, high disposable income,

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awareness of products, rising computer educational level, increased usage of Internet, easy to find review of products [2].

The well-designed websites is the need of hour as design plays a crucial role in the success of online shopping businesses. [3] mention that a well-designed website helps reinforce the firm's brand equity, while a poorly designed website can devalue the established brand equity. Effective web design increases perceived trust of customers. Although online shopping has become a growing new trend, consumers are still not very satisfied with the present design and operation of shopping websites [4]. As a result, there has been a decline in the Internet users' rate of satisfaction [5]. Thus, the companies involved are paying serious attention in the design and development of online shopping websites as they symbolize customer satisfaction [6]. This has forced designers and engineers involved in the process to look out for some novel methods to build well designed websites. A pool of methods has been utilized in the past for website designing but none of them proved much effective. Recently, the use of Quality Function Deployment (QFD) has been reported and the results were quite encouraging. QFD is a customer focused product development process through which the quality of the product can be enormously improved [7]. QFD is a strong decision making technique that helps in effectively taking the decisions involved in the process. The QFD process requires various inputs which are also in the form of linguistic data that is quite vague and subjective [8]. Although it is really important to overcome the vagueness and imprecision in human thought for operative judgment and decision making, most of the input variables in traditional QFD are represented with crisp numerical values that also cause precise judgments [9]. Albeit QFD greatly aids in effective website design of online shopping, it follows crisp approach that gives rise to uncertainty and vagueness. Thus, the results of QFD can be greatly improved if uncertainty and vagueness involved can be suitably handled. Fuzzy set theory is one of the widely used techniques that can better address this issue. Fuzzy QFD has long been reported in various areas but there is notable absence of fuzzy QFD in designing of online shopping websites. Moreover, QFD comprises of several matrices, is a lengthy process which involves massive data and complex calculations. As a result, dealing with the data manually is quite cumbersome and time consuming. Also, the available

QFD softwares are restricted in functionality and even lack the fuzzy support. This generates a need for a Fuzzy QFD (FQFD) driven software tool. However, development of software tool can be accomplished through the use of suitable programming tools. Enhancement of technology and innovations accelerated the tremendous boom in software industry and has given rise to diversity in programming tools. Due to the availability of wide range of programming tools, it becomes essential to evaluate most efficient one among them. To this end, the paper considers some programming tools, analyzes them and then evaluates out the most apt one through comparative analysis.

II. QUALITY FUNCTION DEPLOYMENT (QFD)

QFD is one of the most important methods to satisfy the customers and to transform customers' requirements into design aims [10]. QFD was originally designed and implemented by Yoji Akao in the late 1960. [11] defined it as "a method for developing a design quality aims at satisfying the customer and then translating the customer's demands into design targets and major quality assurance points to be used throughout the production stage". [12] explained the design benefits of QFD as: fewer and early design changes, less time in developments, fewer start-up problems, lower start-up costs, fewer field problems, more satisfied customers, and the identification of comparative strengths and weaknesses of products with respect to competition. The QFD comprises several different parts or rooms, which are sequentially filled in order to achieve an actionable translation from requirements into characteristics [13]. The central tool of the QFD is the matrix chart called House of Quality (HOQ). This tool is a powerful way of generating specific, prioritized and measurable technical requirements from often ambiguous customer needs. QFD uses the HOQ as a visual model as shown in Fig. 1.

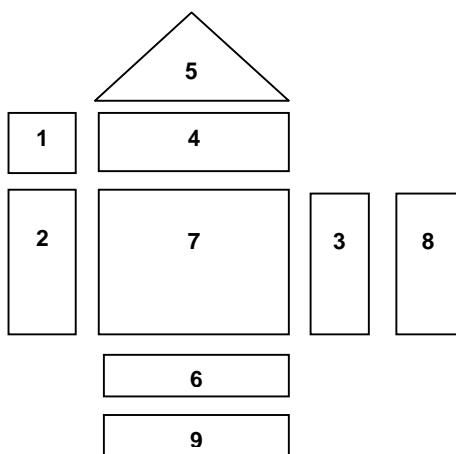


Fig 1: Basic building blocks of house of quality – QFD

There are certain steps that need to be completed to fill the HOQ. The steps are:

4.3.1 Room #1: Identify the product

4.3.2 Room #2: Determine Customer Needs

- 4.3.3 Room #3: Determine Priority Rating
- 4.3.4 Room #4: Develop Technical Requirements
- 4.3.5 Room #5: Correlate Technical Requirements
- 4.3.6 Room #6: Develop Targets for Technical Requirements
- 4.3.7 Room #7: Quantify Central Relationship Matrix
- 4.3.8 Room #8: Quantify Customer Assessment
- 4.3.9 Room #9: Quantify Technical Design Assessment

III. FUZZY CONCEPTS

Decision making involves dealing with doubts, vagueness and uncertainties. Probability theory can represent the stochastic nature, but is unable to measure the inaccuracies or uncertainty that stem from human behavior. Sometimes when the values cannot be defined precisely, the evaluations or opinions are expressed in linguistic terms and so on [14] [15]. Fuzzy logic can be used in such situations. Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. Lofti Zadeh in the 1960s. It deals with imprecise data and handles imprecision [16]. Fuzzy set theory has been proven as a useful tool in modeling the intuition, vagueness, and imprecision in decision-making or optimization problem [17]. A broader view on the fuzzy set theory and STFNs has been provided by [18]. Let $X = \{x\}$ be a traditional set of objects, called the universe. A fuzzy set F in X is characterized by a membership function $\mu_F(x)$ that associates each object in X with a membership value in the interval $[0,1]$, indicating the degree of the object belonging to F . A fuzzy number is a special fuzzy set when the universe X is the real line $R_1: -\infty < x < +\infty$. A STFN denoted as $F = [a, c]$ is a special fuzzy number with the following symmetrical triangular type of the membership function: $\mu_F(x) = 1 - |x - (c+a)/2| / [(c-a)/2]$ where $a \leq x \leq c$. STFN is widely used in practice to represent a fuzzy set or concept F = "approximately b " where $b = (a+c)/2$. Thus, to capture the vagueness of customer subjective assessment on a particular TR having crisp value 9 is represented using STFN [8,10] and the membership function for this is: $\mu_{[8,10]}(x) = 1 - |x - 9|$ where $8 \leq x \leq 10$ [19]. Table 1 below depicts the Linguistic Term and their Fuzzy Numbers.

Table 1: Linguistic Term and their Fuzzy Numbers

	Linguistic Term	Fuzzy Number
(VH)	Very High	(8,9,10)
(H)	High	(6,7,8)
(M)	Medium	(4,5,6)
(L)	Low	(2,3,4)
(VL)	Very Low	(0,1,2)

IV. SOFTWARE AUTOMATION

Automation of an application has never been simplistic. Moreover, the task gets more strenuous if the business to automate happens to be too lengthy as it may involves enormous data, numerous calculations and more time-consuming processes. Automation of such task enforces meticulous examination of the processes involved, gathering of data and then transcribing these data into the technical slabs for effective utilization. Besides, it is also concerned with the tools selected for the automation purpose. Development of a software application can be accomplished using different programming tools however, what carries importance is not the completion of task but the flexibility and efficiency that it offers [20]. Programming language acts as a cornerstone in software development and hence selecting a suitable one is of paramount importance in this regard. Different programming languages have their advantages and disadvantages, and picking the appropriate language for the task is often an important step in the process of developing an application or software. This generates a need to explore and select a suitable programming language for the software automation. Given the focus of this study, several languages need to be considered as possible choices for the purpose, evaluated against proposed software tool development and a suitable one has to be finalized.

A. Programming Languages

The programming tools may be any software program or utility that aids software developers or programmer in creating, editing, debugging, maintaining and / or performing any programming or development- specific task [21]. It provides the support to accomplish the particular task within the development phase of programming cycle. The development phase requires use of certain programming language. Here, the development of proposed software system can be better achieved using following languages:

1. C

C is one of the popular general purpose high-level programming languages used for the development of system and application software. C is born at 'AT & T's Bell Laboratories' of USA in 1972. It was developed by Dennis Ritchie. This language was created for a specific purpose: to design the UNIX operating system (which is used on many computers). C is suitable for systems-programming applications, hardware related applications, embedded device, chip designing, and industrial automation products [22]. Despite being fairly old programming language, C programming is widely used because of its efficiency and control [23]. C does not include the include some most important features found in modern high level languages such as object orientation and garbage collection.

2. C++

C++ is an object oriented programming language which is derived from C. C++ was developed by Bjarne Stroustrup at AT & T, Bell Labs during 1983-1985. C++ is an addition of C. Prior to 1983; Bjarne Stroustrup added

features to C and produced 'C with Classes'. "C++ was designed for the UNIX system environment, it represents an enhancement of the C programming language and enables programmers to improve the quality of code produced, thus making reusable code easier to write" [22]. Many programming languages are influenced by C++, including java, C# etc. C++ is suitable for the software development such as application software, device drivers and high-performance server. When compare C++ with assembly languages, C++ is high level, but although it consists of many low level features to directly manipulate the computer's memory. Hence C++ is excellent language for writing performance software systems [24].

3. Java

Java language is very powerful language which facilitates to develop all kinds of application software for its simple and efficient, widely used. Java started to be developed in 1991 by James Gosling from Sun Microsystems and his team. The original version of Java is designed for programming home appliances. In 1994, James Gosling started to make a connection between Java and internet. Netscape Incorporated launched its latest version of the Netscape browser which was capable of running Java programs in 1995. While Java is viewed as a programming language to design applications for the Internet, it is in reality a general all-purpose language which can be used independent of the Internet. [22] Java comprises of three different type, Java2 Standard Edition (J2SE), Java2 Micro Edition (J2ME), and Java2 Enterprise Edition (J2EE). J2SE is appropriate for the desktop applications. While J2ME is appropriate for embedded systems development for mobile phones, wireless application and PDA programming. Ultimately, J2EE is proper for the development of server programming. Java implementation of the Hot Java browser (Java applet support) shows the charm of Java: cross-platform, dynamic Web, Internet computing. Java has been widely accepted and promoted the rapid development of the Web since then [25]. Once compiled, java program can be run in a variety of systems.

4. Visual Basic 6.0 (VB6)

Visual Basic (VB) is high level programming language that is easy to learn than other programming language. It is evolved from earlier version of DOS know as BASIC, where basic stand for Beginners' All-Purpose Symbolic Instruction Code. It is mainly used to develop window based applications and games. VB is a very widely used tool, bundled with numerous features and controls that assist in developing applications on the fly. It enables rapid application development of graphical user interface applications. VB is a sophisticated language that is powerful, is highly integrated with C, C++, Visual C++ and Java related languages. That is, it is easy to import subroutines from these languages to VB. A main advantage of VB is the ease in which complex forms can be generated [26].

5. VB.Net

VB.Net is simple, modern, object-oriented computer programming language developed by Microsoft to combine power of .net framework and the common language runtime with productive benefits that are hallmark of visual basic [27]. Just like classic VB included more and more great controls as year went by, Microsoft released the enhanced version in .net package as VB.Net for VB programmers with some additive functionality. VB.Net has many improved features such inheritance, overloading, interface etc which makes it more powerful object oriented programming language. It fully integrates .Net framework and common language runtime, which provide language interoperability, garbage collection, enhanced security and improved versioning support [28].

V. PROGRAMMING TOOLS: EVALUATION AND JUSTIFICATION

Evaluation of programming tool is prerequisite to gain better conceptual understanding of software development. The approach for achieving the required perspectives of software may be different for different programming tools. Thus, it becomes sturdily required to evaluate the most efficient programming tool which can offer the desired objectives for the development of proposed software tool in a most effective way. Different programming languages support different styles of programming called programming paradigms. The selection of language used includes many considerations, such as relevance to task, availability of third-party packages, company policy or individual liking. The programming language is an integral part in any software development process and the selection of a particular language involves delving into many aspects like understanding the nature of the application, chalking out important modules of the application, understanding them, finding the computations involved, etc. The best tool for the job is the one that best conforms to requirements, limitations and expectations. In this regard, the following section examines the QFD process from the software automation point of view and highlights the main modules of QFD exercise. QFD is based on the widely used four-phase model, which focuses on the quality deployment part of Akao's comprehensive QFD framework. The four phases represent product planning, component planning, process planning and production planning. HOQ is the heart of any QFD application. In addition to the HOQ matrix, QFD utilizes several management and planning tools and some main processes, which are used in many of its procedures:

- Voice of customer
- Brainstorming
- Affinity diagrams
- Benchmarking
- Hierarchy trees
- Matrices and tables

QFD is an exercise that comprises set of matrices, is a lengthy process, and involves understanding many concepts, dealing with massive data and complex calculations [20]. QFD also includes presenting data in hierarchical tree format and representing the data in graphical form. QFD encompasses several parameters (Refer Figure 2), as a result, dealing with the data manually is quite cumbersome and time consuming. Thus, the software has to be fast and simple in usage to prepare tables and matrices in which correlations between requirements and attributes can be determined and the necessary indicators can be calculated. The construction of the matrices should be flexible due to changing requirements [29]. Amongst the above languages, not all but some have been used in the research work. It is quite imperative to make a proper selection beforehand. Study from the software automation perspective reveals that the programming language should support the following features:

- Supports GUI applications
- Enables the RAD
- Powerful and efficient
- Strong database support
- Drag and drop features
- Rich built-in controls.

Figure 2 explices the nature of QFD. Analysis reveals that the QFD driven application can be better automated with a general purpose programming language. Besides the general features required in any language, some functionality like – displaying data in hierarchical tree structure, displaying charts and graphs, drag and drop operations, strong database interaction are required to be implemented in QFD. Several languages are considered for the development of software and their nature and areas of applications are presented. The presented languages can be used for the development of proposed software tool.

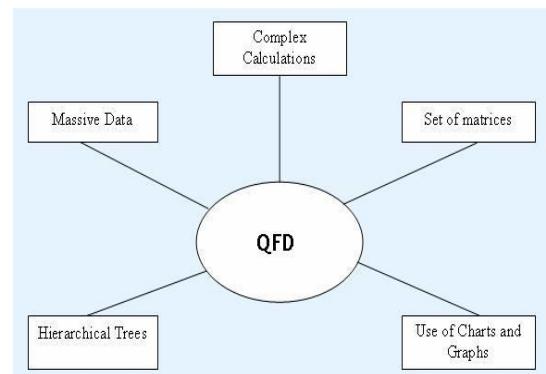


Fig 2: Parameters in QFD

The aforesaid features required are either difficult or impossible with other languages. Some languages lack either drag and drop support, some are not GUI, some do

not have database support or some do not have support for faster development. Keeping in view of nature of QFD, amongst the various programming languages presented, Java, VB and VB.Net emerged out to be the possible choices for development of software. Since VB.Net is much powerful and advanced than VB, so VB.Net takes preference over VB which makes VB.Net and Java as final choices for proposed software tool. Both of them have their own strengths and weakness. Both of them are capable of producing high end applications. Thus, VB.Net and Java appear as apt choices for development of the proposed software tool. By comparing these two against the proposed software tool on certain aspects like Ease of Use, Speedy Development, several needed built in features. VB.Net gets the upper hand as it has a pile of fast easy syntax, components, events, etc... all built in. It provides more user friendliness when designing the forms. For example, in VB.Net we can drag and drop controls into form that saves developer not only from unnecessary onus of writing several lines of code but also aids developer to concentrate on the logic or other security issues whereas in java, code for creating a simple control like button also takes a lot of programming for a developer. In QFD, Affinity Process is highly needed to synthesize high volume of unstructured, disorganized and repetitive data collected from customers into handful of information to represent the actual customer needs. This can be conveniently done using built in controls 'Listview' and 'Treeview' offered by VB.Net by employing drag and drop utility along with these controls. The uncertainty and vagueness involved in QFD can be overcome through fuzzy integration. There are various fuzzy numbers that can be employed for the purpose like Trapezoidal, Triangular Symmetrical Triangular Fuzzy Numbers (STFNs) etc. Amongst these numbers, STFNs are chosen over others as they are easy to understand and implement and are convenient from computation point of view. Besides, the nature of STFNs allows it to be suitably implemented with any programming language. The implementation of fuzzy integration can be easily achieved in VB.Net. Likewise, the other needed features can be better accomplished using VB.Net as compared to Java. VB.Net offers an ease of programming, is an event-driven language that has almost all the above-required features. Thus, VB.Net fits the bill in the development of proposed software tool.

VI. CONCLUSION

Presently, the myriads of programming tools are available that assists in developing software. Each of the tools has their style, approach and areas of applicability; it is highly needed to evaluate an apt one for software development. This research work considers fuzzy-QFD driven software tool for effective design of online shopping websites designing and thus in this regard the work has considered some programming tools and presented the comparative analysis for proposed software development. The QFD process is explored and important modules and the parameters involved are highlighted. Integration of fuzzy concepts has also been analyzed from software automation perspective. It has been realized from the study that amongst the various languages considered, VB.Net and

Java appeared out as possible choices. However, further analysis between the two languages yielded VB.Net to be more suitable for proposed software development.

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